CLAIMS

What is claimed is:

1. A power line isolation loss detector for determining the magnitude and polarity of a difference between a high side current and a low side current, the isolation loss detector comprising:

a high side thermal generator coupled to the high side current and a low side thermal generator coupled to the low side current, the high side thermal generator and the low side thermal generator providing high side and low side sets of temperatures indicative of the high side and low side current respectively;

a temperature difference sensing module thermally coupled to the high side and low side thermal generators and configured and arranged to sense the high side and low side sets of temperatures and to provide a set of temperature difference sensor output signals indicative of the magnitude and polarity of a difference between the sensed high side and low side sets of temperatures;

a control module coupled to the temperature sensor output voltage and in the event that the magnitude of the temperature sensor output voltage exceeds a predetermined threshold, the output module being operative to selectively disconnect the high side and/or low side current based on the polarity and magnitude of the of the temperature sensor output voltage.

2. The power line isolation loss detector of claim 1 wherein the high side set of temperatures includes a single high side temperature indicative of the high side current and the low side set of temperatures includes a single low side temperature indicative of the low side current.

3. The power line isolation loss detector of claim 2 wherein the temperature difference sensor includes a high side temperature sensor thermally coupled to the high side thermal generator, the high side temperature sensor operative to sense the single high

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side temperature and a low side temperature sensor thermally coupled to the low side thermal generator, the low side temperature sensor operative to sense the single low side temperature and wherein the set of temperature difference sensor output signals includes a single temperature difference output signal.

4. The power line isolation loss detector of claim 3 wherein the temperature difference sensing module includes at least one Seebeck temperature sensor.

5. The power line isolation loss detector of claim 3 wherein the high side thermal generator includes a first low-resistance shunt disposed in series with the high side current and the low side thermal generator includes a second low-resistance shunt disposed in series with the low side current wherein each low-resistance shunt produces a temperature that is proportional to the square of the high side and low side current respectively.

6. The power line isolation loss detector of claim 1 wherein the high side thermal generator includes a high side thermal difference generator that provides first and second high side temperatures and the low side thermal generator includes a low side thermal difference generator that provides first and second low side temperatures.

7. The power line isolation loss detector of claim 6 wherein the high side set of temperatures includes the first and second high side temperatures and the low side set of temperatures includes the first and second low side temperatures.

8. The power line isolation loss detector of claim 7 wherein the temperature difference sensing module includes a high side

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temperature difference sensor thermally operative to sense the first and second high side temperatures and a low side temperature difference sensor operative to sense the first and second low side temperatures and wherein the set of temperature difference sensor output signals includes the difference between the sensed firs and second high side temperatures and the difference between the first and second low side temperatures.

9. The power line isolation loss detector of claim 6 wherein the high side thermal generator includes a high side Peltier thermal difference generator and the low side thermal generator includes a low side Peltier thermal difference generator.

10. The power line isolation loss detector of claim 6 wherein the temperature difference sensing module includes at least two Seebeck temperature sensors.

11. A power line isolation loss detector for determining the magnitude and polarity of a difference between a high side current and a low side current, the loss detector comprising:

a high side thermal generator connected in series with the high side current producing a first temperature as a function of the high side current;

a low side thermal generator connected in series with the low side current producing a second temperature as a function of the low side current;

a temperature difference sensor thermally coupled to the first and second thermal generators, the temperature difference sensor operative to sense the first and second temperatures and to provide a temperature sensor output voltage indicative of the magnitude and polarity of a difference between the sensed first and second temperatures;

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a control module coupled to the temperature sensor output voltage and in the event that the magnitude of the temperature sensor output voltage exceeds a predetermined threshold, the output module being operative to selectively disconnect the high side and/or low side current based on the polarity and magnitude of the of the temperature sensor output voltage.

12. The power line loss detector of claim 11 wherein the high side thermal generator includes a high side resistor circuit having a high side resistance, the first resistor coupled to the high side current, wherein the high side resistor circuit dissipates heat according to the first resistance multiplied by the square of the high side current;

low side thermal generator includes a low side resistor circuit having a low side resistance, the second resistor coupled to the low side current, wherein the low side resistor circuit dissipates heat according to the second resistance multiplied by the square of the low side current; and .

the temperature difference sensor includes a thermopile having a plurality of Seebeck temperature sensing transducers, wherein each of the Seebeck temperature sensing transducers includes a first temperature sensing junction thermally coupled to the high side thermal generator and a second temperature sensing junction thermally coupled to the low side thermal generator.

13. The power line current loss detector of claim 12 wherein the high side resistor circuit of the high side thermal generator includes first and second elongated resistors electrically connected in series;

the low side resistor circuit of the low side thermal generator includes third and fourth elongated resistors electrically connected in series;

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the first, second, third, and fourth resistors physically configured and arranged parallel to one another and the third and fourth resistors interposed between the first and second resistors;

the plurality of Seebeck temperature sensing transducers including a first and second plurality of Seebeck temperature sensing transducers, wherein the first plurality of the Seebeck temperature sensing transducers includes a first temperature sensing junction thermally coupled to the first resistor and a second temperature sensing junction thermally coupled to the third resistor; and

the second plurality of the Seebeck temperature sensing transducers includes a first temperature sensing junction thermally coupled to the fourth resistor and a second temperature sensing junction thermally coupled to the second resistor.

14. The power line loss detector of claim 13 wherein each of the first and second plurality of the Seebeck temperature sensing transducers includes a silicon substrate, a field oxide layer disposed on top of the silicon substrate, a gate consisting of a first conductor, and a first and second thermal difference sensing junctions formed on the gate in a spaced apart configuration, the first and second thermal difference sensing junctions formed by second and third conductors each being dissimilar to the first conductor, wherein the first and second thermal difference sensing junctions provide a voltage output that is a function of the difference in temperature between the first and second thermal difference sensing junctions.

15. The power line loss detector of claim 11 wherein the control module includes:

a first positive offset voltage source and a first negative offset voltage source;

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a first comparator having a first input coupled to the temperature sensor output voltage and a second input coupled to the positive output voltage, the first comparator providing a high side warning output voltage ;

a second comparator having a first input coupled to the temperature sensor output voltage and a second input coupled to the negative output voltage, the second comparator providing a low side warning output voltage; and

an OR gate having a first input coupled to the high side warning output voltage and a second input coupled to the low side warning output voltage, the OR gate providing a signal an output warning signal.

16. The power line loss detector of claim 15 further including:

first and second switches coupled to the high side and low side currents respectively, the first and second switches coupled to the OR gate output and responsive to the output warning signal by opening or closing thereby allowing or preventing the high side and low side currents to flow.

17. A power line loss detector for determining the magnitude and polarity of a difference between a high side current and a low side current, the loss detector comprising:

a high side Peltier thermal difference generator electrically connected in series with the high side current, the Peltier thermal difference generator operative to generate first and second high side temperatures, the high side Peltier thermal difference generator including first and second temperature generating junctions, the temperature difference between the first and second temperature generating junctions being a function of the high side current;

a low side Peltier thermal difference generator electrically connected in series with the low side current, the Peltier thermal

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difference generator operative to generate first and second low side temperatures, the low side Peltier thermal difference generator including third and fourth temperature generating junctions, the temperature difference between the third and fourth temperature generating junctions being a function of the low side current;

a high side Seebeck thermal difference sensor having first and second high side pluralities of thermal sensor junctions, the first plurality of temperature sensing junctions being thermally coupled to the first temperature generating junction of the high side thermal difference generator and the second plurality of temperature sensing junctions being thermally coupled to the second temperature generating junction of the high side thermal difference generator, the high side thermal difference generator providing a high side output voltage that is a function of the temperature difference between the first and second high side thermal difference generators;

a low side Seebeck thermal difference sensor having first and second pluralities of thermal sensor junctions, the first plurality of temperature sensing junctions being thermally coupled to the third temperature generating junction of the low side thermal difference generator and the fourth plurality of temperature sensing junctions being thermally coupled to the second temperature generating junction of the low side thermal difference generator, the low side thermal difference generator providing a low side output voltage that is a function of the temperature difference between the third and fourth low side thermal difference generators;

a control module coupled to the high side Seebeck temperature difference sensor and the low side Seebeck temperature difference sensor and receiving the high side output voltage and the low side output voltage, the control module operative to provide indicia as to the difference in magnitude and polarity

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between the high side output voltage and the low side output voltage, wherein the difference between the high side output voltage and the low side output voltage is indicative of the difference between the high side and low side currents, the control module being further operative, in the event that the magnitude of the difference between the high side and low side current exceeds a predetermined threshold, to disconnect the high side and/or low side current based on the polarity and magnitude of the of the difference between the high side output voltage and the low side output voltage.

18. The power line loss detector of claim 17 wherein the high side Peltier thermal difference generator includes:

a silicon substrate;

a first current transfer portion disposed on top of the silicon substrate, the first current transfer portion formed from a first conductive material,

an input conductor formed from a conductive material dissimilar to the first conductive material, the input conductor physically and electrically connected to the first current transfer portion and forming a first temperature generating junction at the junction between the input conductor and the first current transfer portion;

an output conductor formed from a conductive material dissimilar to the first conductive material, the output conductor physically and electrically connected to the first current transfer portion and being spaced apart from the first temperature generating junction, forming a second temperature generating junction at the junction between the output conductor and the first current transfer portion;

the high side thermal difference sensor including first and second pluralities of thermal sensor junctions, the first plurality of temperature sensing junctions being thermally coupled

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to the first temperature generating junction of the high side thermal difference generator and the second plurality of temperature sensing junctions being thermally coupled to the second temperature generating junction of the high side thermal difference generator, the high side thermal difference generator providing a high side output voltage that is a function of the temperature difference between the first and second high side temperature difference generators.

19. The power line loss detector of claim 17 wherein the low side Peltier thermal difference generator includes:

a silicon substrate;

a third current transfer portion disposed on top of the silicon substrate, the first current transfer portion formed from a first conductive material;

an input conductor formed from a conductive material dissimilar to the first conductive material;

the input conductor physically and electrically connected to the first current transfer portion forming a first temperature generating junction at the junction between the input conductor and the first current transfer portion;

an output conductor formed from a conductive material dissimilar to the first conductive material;

the output conductor physically and electrically connected to the first current transfer portion spaced apart from the first temperature generating junction, forming a second temperature generating junction at the junction between the output conductor and the first current transfer portion;

the high side thermal difference sensor including first and second pluralities of thermal sensor junctions, the first plurality of temperature sensing junctions being thermally coupled to the first temperature generating junction of the high side thermal difference generator and the second plurality of

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temperature sensing junctions being thermally coupled to the second temperature generating junction of the high side thermal difference generator, the high side thermal difference generator providing a high side output voltage that is a function of the temperature difference between the first and second high side temperature difference generators.

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